Applications for Maritime Situational Awareness

Egbert Schwarz

German Aerospace Center (DLR)

Earth Observation Center (EOC)
Maritime Security Lab Bremen | Neustrelitz

ASIAN SPACE TECNOLOGY SUMMIT
11TH & 12TH MAY 2017 @ KUALA LUMPUR

Presentation Outline

Introduction

DLR Maritime Application Development

- Ship detection
- Wind and Wave
- Oil Detection

Project example

- Real Time Service for Maritime Security
  (**E**chtzeitdienste für die **M**aritime Sicherheit – **Sec**urity; EMSec)

Current Development

- Real Time Service for Navigation on Ice

Conclusion

German Aerospace Center, DLR

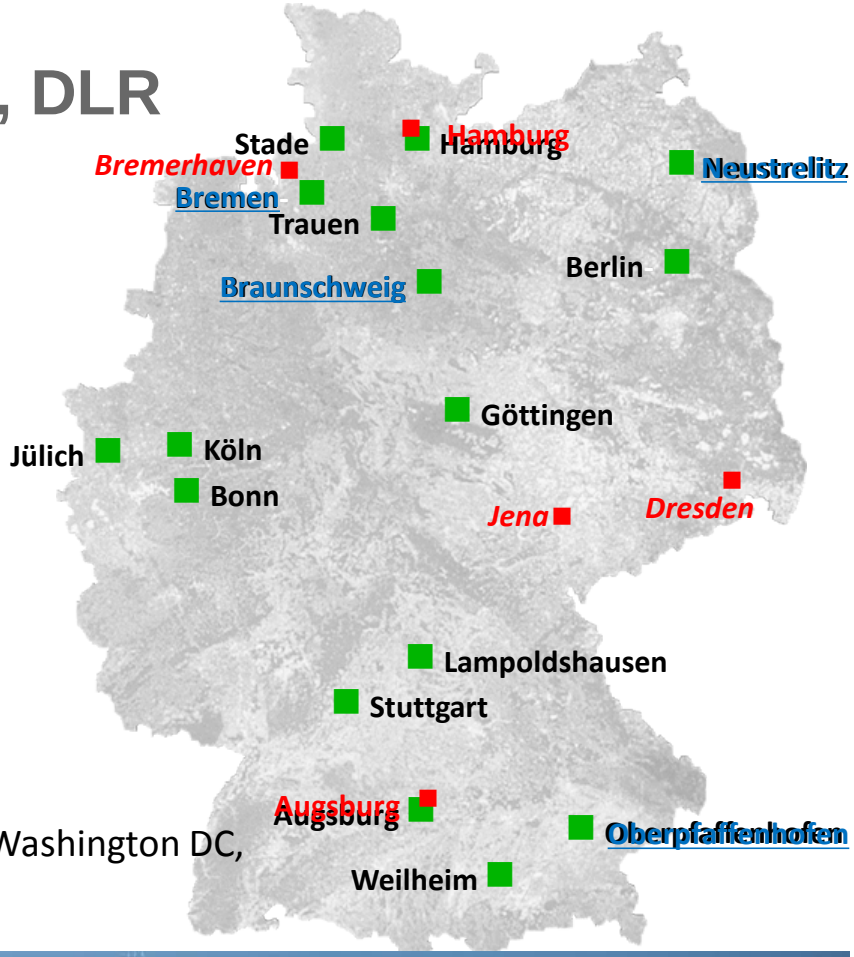
Germany's National Research Center for Aeronautics, Space, Energy, Transport & Security.

Space Agency

Project Management Agency
~ 8000 employees

39 research institutes and large test facilities at 20 sites across Germany

2 Ground stations in O'Higgins (AQ), Inuvik (CA)



5 Liaison offices in Berlin, Brussels, Paris, Tokyo, Washington DC,

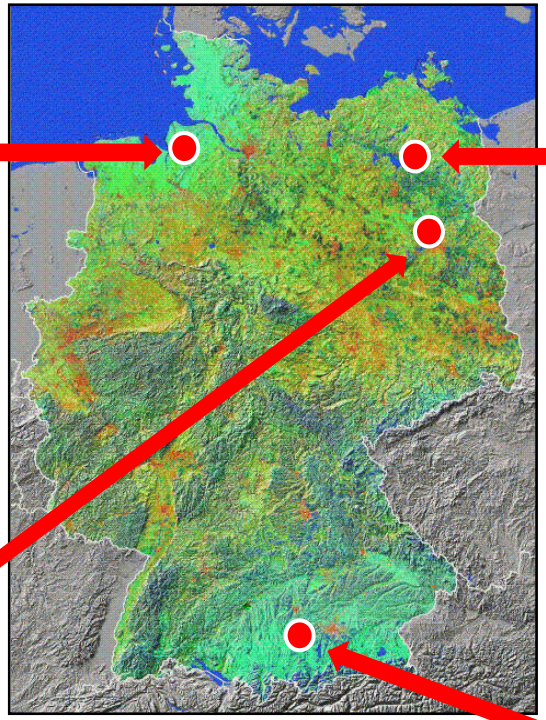
4 Maritime Security Lab's

Maritime Safety and Security

Earth Observation Center – EOC

2 Institutes , German Remote Sensing Data Center (DFD) & Remote Sensing Technology Institute (IMF)

Bremen
Maritime Security Lab



Neustrelitz
National Ground Segment
Maritime Security Lab

Berlin

- Appr. 350 employees at 4 sites
- Chairs at 2 universities
  (Würzburg, Munich)

Oberpfaffenhofen

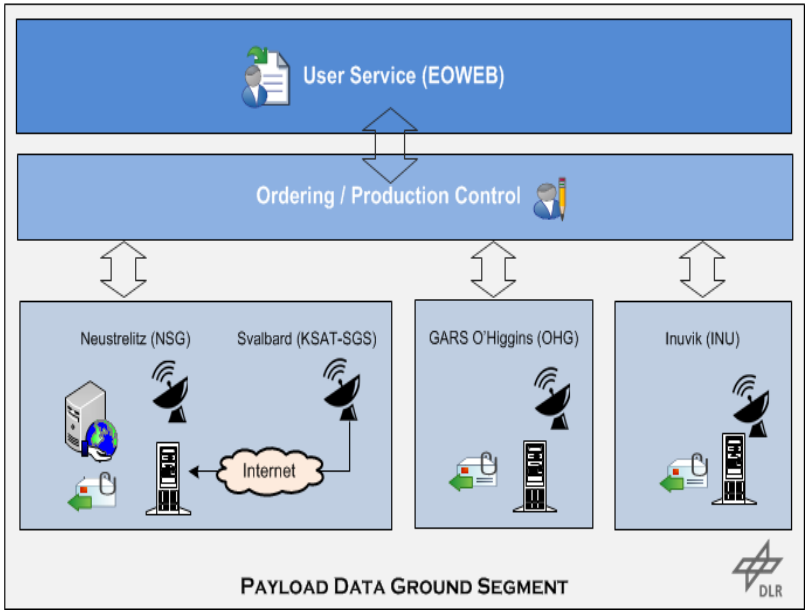
DLR

Neustrelitz Ground Station

- Ground Station and Processing Facility Neustrelitz support of currently 21 different Satellite missions
- **Main reception and processing facility for SAR Mission TerraSAR-X (TerraSAR-X/ TanDEM-X)**
- Collaborative Station for European Copernicus mission Sentinel-1 (Sentinel-1A/ Sentinel-1B)
- Radarsat-2 Regional Ground System
- Landsat-8 Global Network Station, United States Geological Survey (USGS)
- CartoSAT, ResourceSat, Oceansat supporting Gesellschaft für Angewandte Fernerkundung (GAFAG)
- Kompsat 3, 3A, 5 supporting Korea Aerospace Research Institute (KARI)

TerraSAR-X Capabilities

- Morning and evening timeline upload for a 12 h desirable / 12 h critical timeline with order deadline a few hours before
  - for data take at end of timeline: allow about 17 hours for tasking
  - based on satellite TSX or TDX acquisition
- Near real time product latency after downlink: about 15 – 30 minutes
- No orbit information available in X-band downlink
  - usage of predicted orbit information only
- NRT ground station pool (Neustrelitz, Svalbard)
  - online raw data transfer to Neustrelitz
- Mission planning uses next possible pool contact for NRT downlink



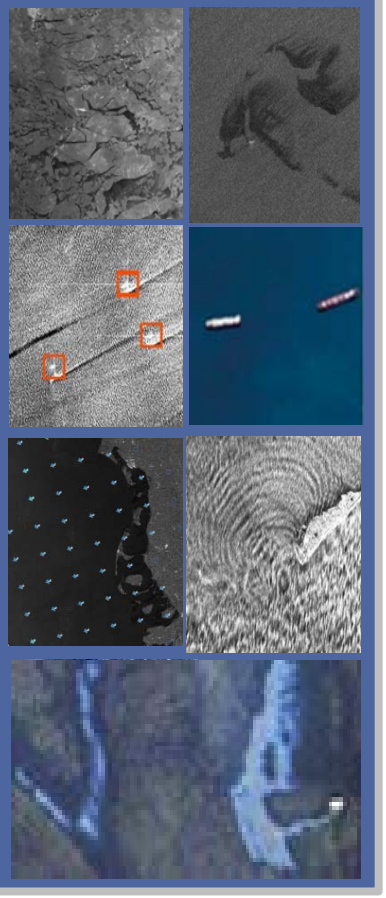
DLR TerraSAR-X Payload Data Ground Segment

Objective of the Maritime Security Lab Neustelitz

Research and development of integrated applications enabling specific value added
Maritime Information Products for the Maritime Situational Awareness in Near Real Time

Application 》

Ice
Oil
Ship
Wind
Wave
Activity
Change



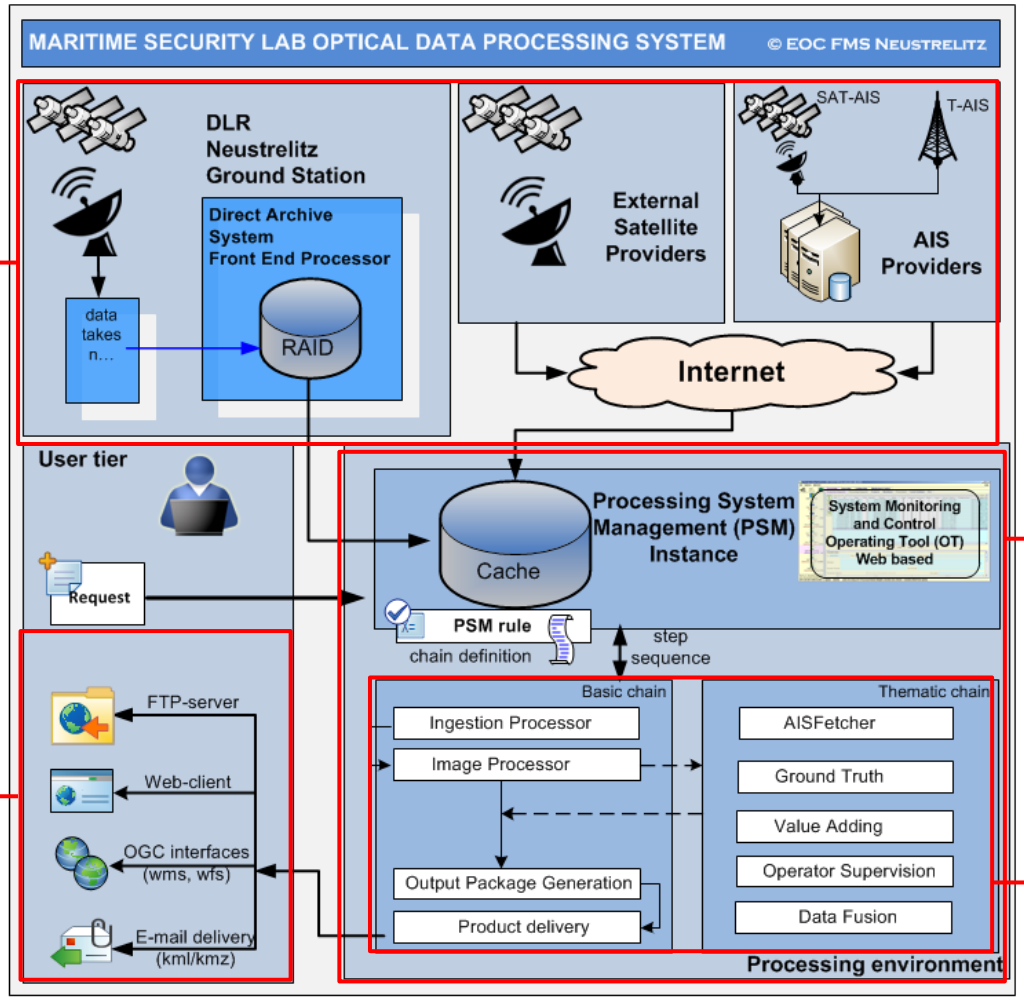
Architecture of Service Chain

DATA Collection

Product Dissemination

Processing environment

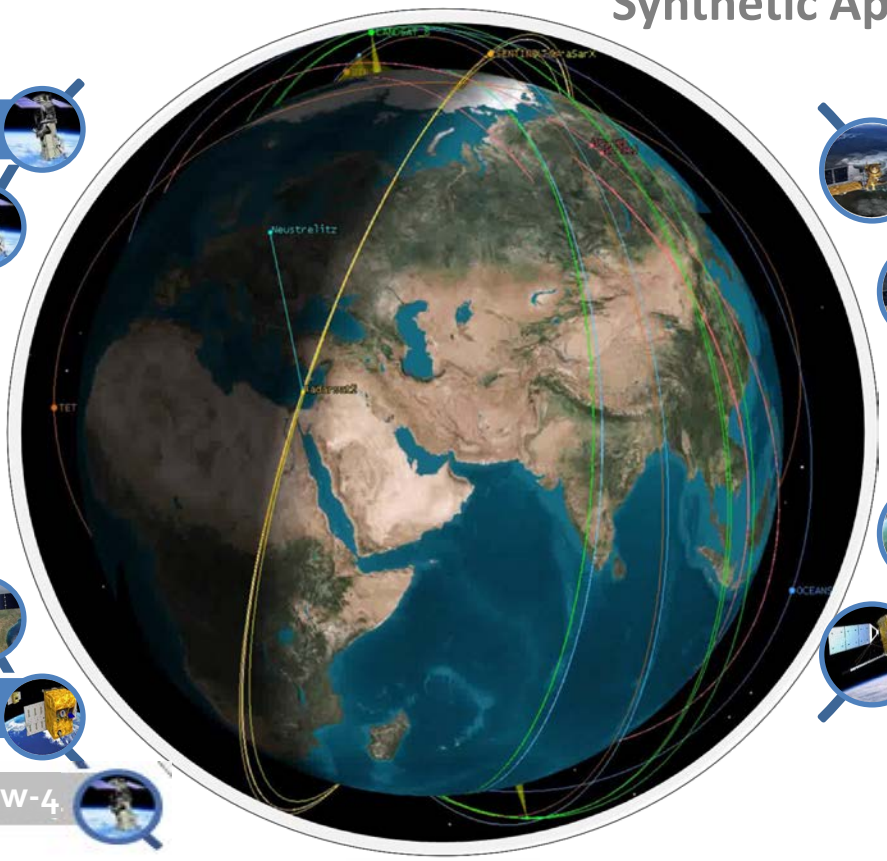
Processing Rules and Processors



Space Capabilities

Optical

- Worldview-1
- Worldview-2
- Worldview-3
- GeoEye-1
- Deimos-2
- Landsat-8
- Firebird
- Worldview-4



Synthetic Aperture Radar (SAR)

- Sentinel-1A
- Sentinel-1B
- TerraSAR-X
- TanDEM-X
- Radarsat-2

Automatic Identification System

Terrestrial AIS 


Satellite AIS

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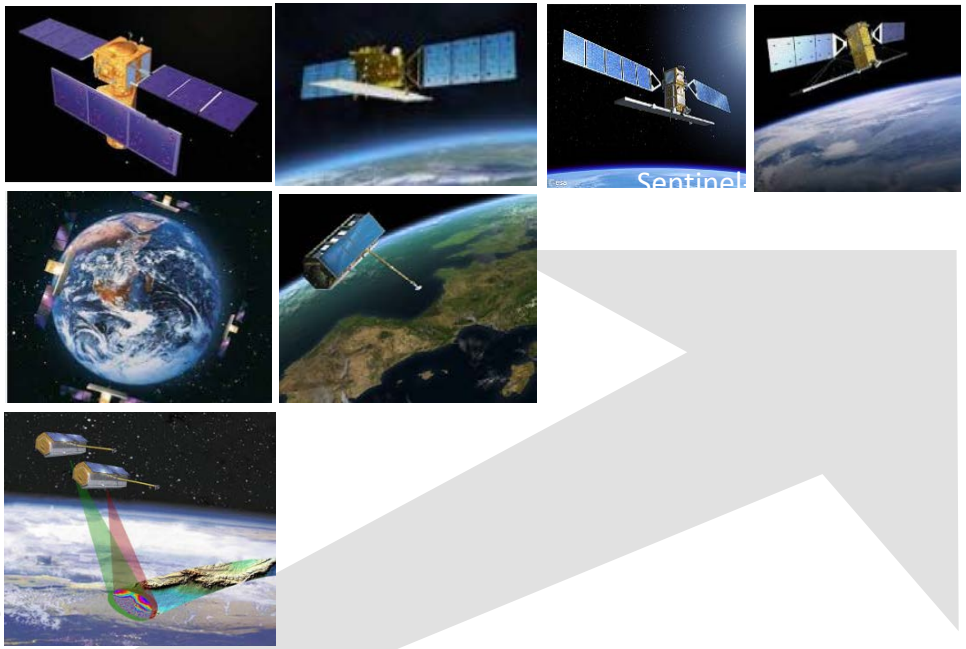
Space Capabilities

- Number of Satellites and Satellite Constellations increase
- Higher Number of small satellites, with lower costs of manufacture, launch, and operations
- Increased revisit time and flexibility
- Higher Coverage update and higher image resolution
- Higher service reliability
  - ➢ More data
  - ➢ New Products
  - ➢ Shorter response time



Operational Satellites Application	2015	2016
Earth Observation	333	374
Communications	705	713
Technology Demonstration	141	160
Navigation and Global Position	91	105
Space Science	65	67

sats-orbit 2015 | 2016 http://www.pixalytics.com

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Merit and Constrains of Remote Sensing using Synthetic Aperture Radar (SAR)

Alos-2
CosmoSkymed
Kopsat-5
Radarsat-2
Risat
Sentinel-1
TerraSAR-X
TanDEM-X

- SAR satellite data enable day/night monitoring independent from weather (clouds) and semi automated feature extraction
- Increasing number of satellite resources
- different types of sensors and sensor modes (coverage, resolution)
- SAR processing enable fast processing of large volumes of data and information delivery within 15 - 30 minutes of image acquisition
- data quality and false alarms constraints require operator supervision e.g. for vessel detection application

- Manly dusk dawn orbits
- tasking nominal twice per day
- SAR instrument orbit duty cycle, revisit and coverage capabilities
- Order (static planning cycle | user competition | dual use)
- Pricing e.g. emergency tasking and very high resolution

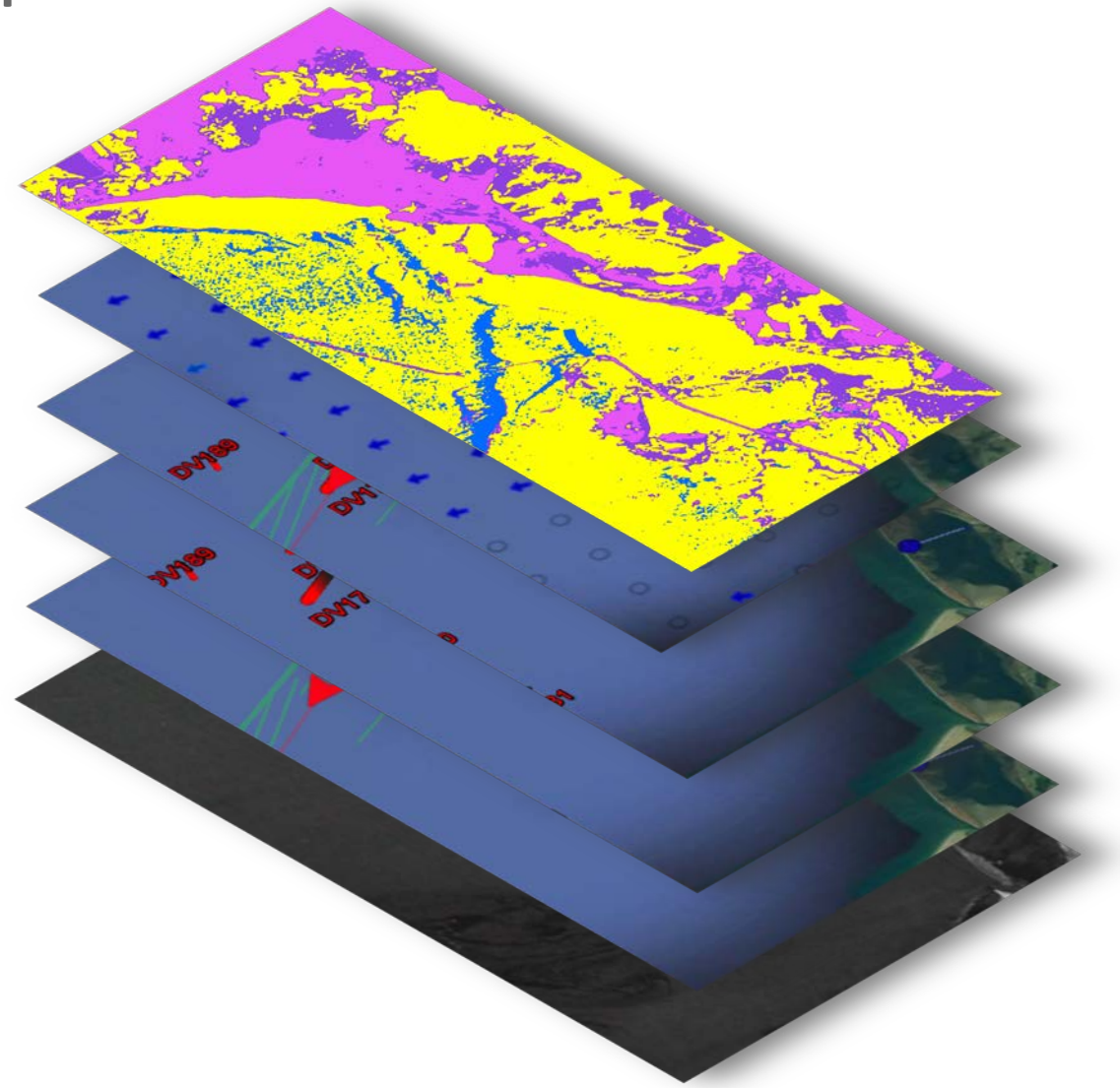
Merit and Constrains of Remote Sensing using very high resolution optical data

GeoEYE-1
Deimos-2
Pleiades
Planet
Kopsat-3, 3a
Worldview 1-4

- Very High resolution up to 31 cm panchromatic , up to 1.24 m multispectral resolution , 3,7 m short-wave infrared resolution
- High agility and flexibility, e.g. acquisition of coastlines
- Increasing number of satellite resources and satellite constellations e.g. Digital Globe, AIRBUS, Deimos, Kompsat, Planet
- Monitoring dependents on weather situation clouds
- Order, e.g. user competition and dual use
- Limited near real time capabilities compared to SAR
- Pricing, expensive

Thematic Processing Chain

- Automated processing
  - Target detection
  - Data fusion
  - Wind
  - Wave
- Semi automated algorithms
  - Target detection
  - Activity detection
  - Change detection
  - Data fusion
- Operator Interface
  - GUI with 3D viewer



Thematic Processing Chain

- Automated algorithm
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  - Change detection
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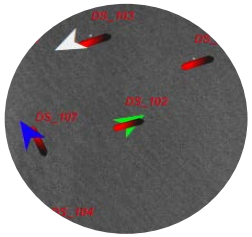
- Operator Interface
  - GUI with 3D viewer

Operator GUI of Analysis Framework (client side)
WorldView 3 © 2016, 2017 Digital Globe, Inc. provided by European Space Imaging

Ship- Detection Application (SAR)



Near real time
ship detection application
based on SAR images and AIS

currently developed for:

- TerraSAR-X,
- TanDEM-X
- CosmoSkyMed
- Radarsat-2,
- Sentinel-1A,
- Sentinel-1B

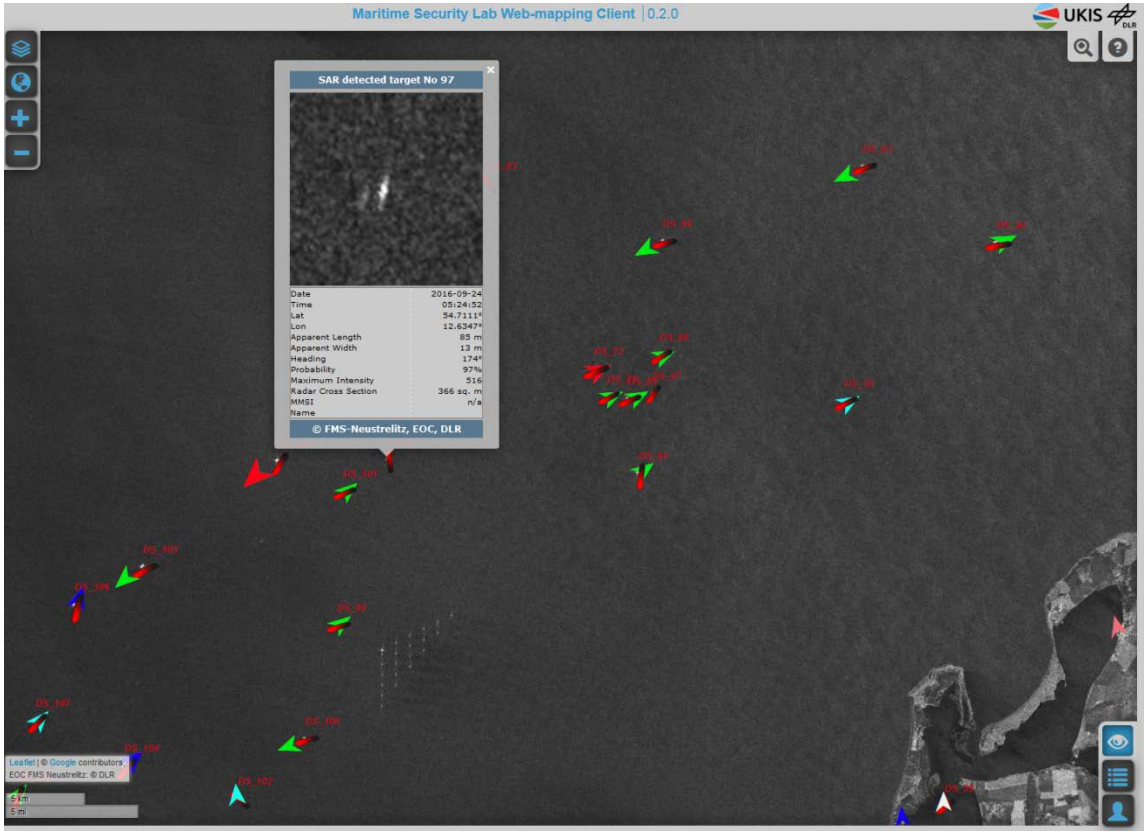
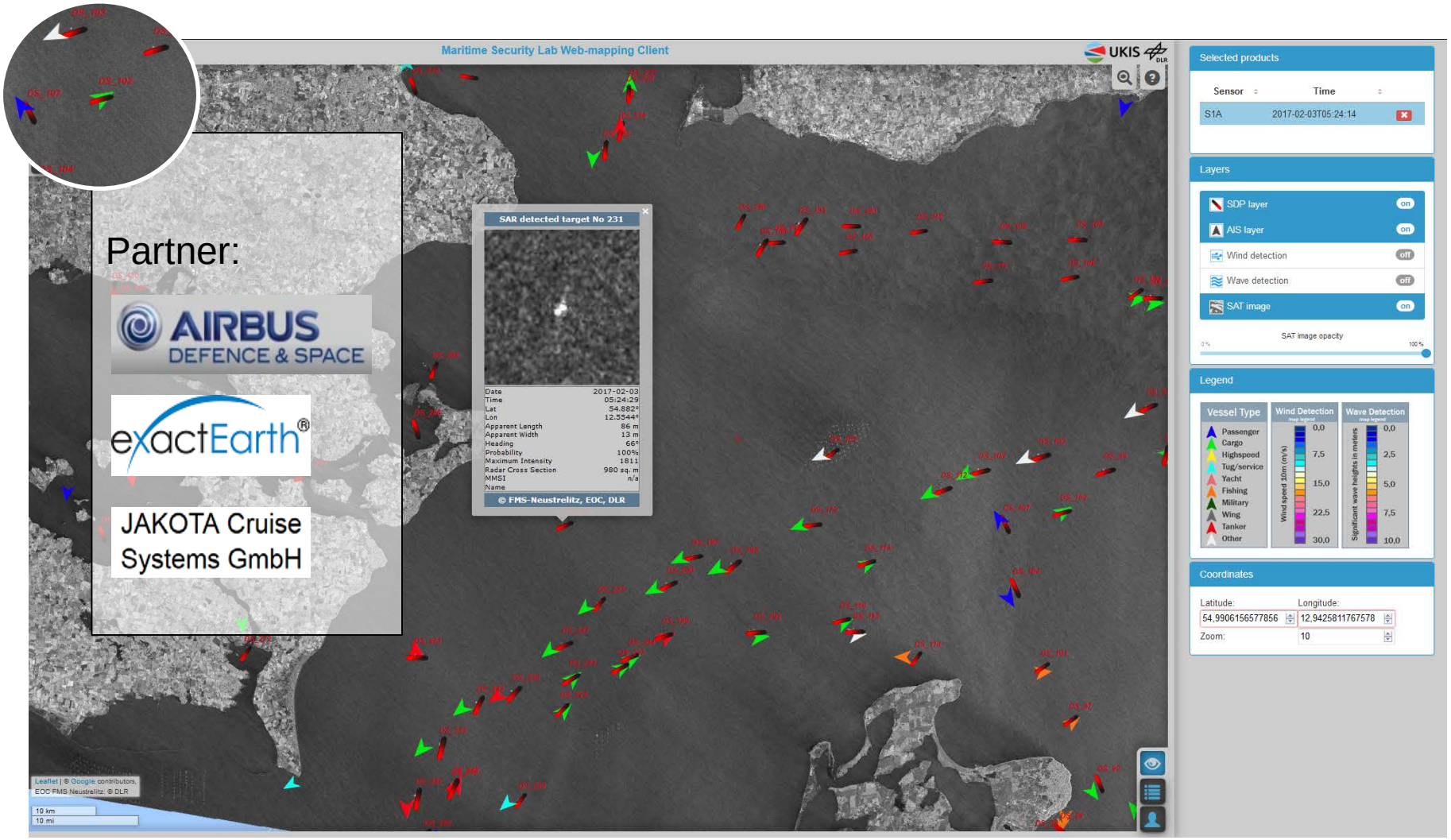


Image: S1A_IW_GRDH_1SDV_20160924T0524

Value added products

- **SAR/ AIS merged products** (in case of available AIS Data)
- ASCII ; KMZ, GML; DER (EMSA); ESRI shape; JSON;
- GeoTIFF (MRES_L1b; HRES_L1B)

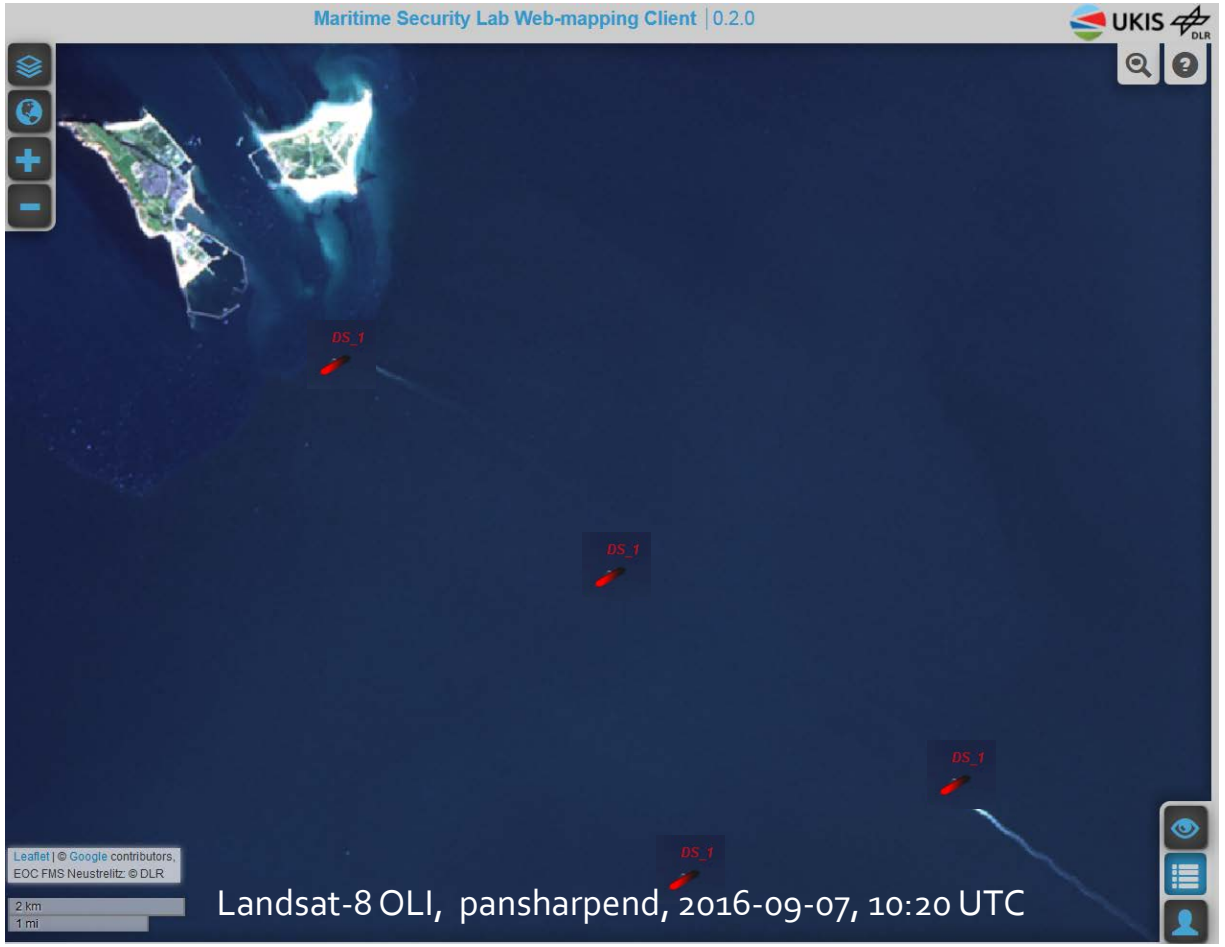
Ship- Detection Application (SAR)



Ship- Detection Application (Optic)

Near real time ship detection application based on optical data
Core processor currently being developed by the Maritime Security Lab Neustrelitz

value added products in near real time based on high and very high resolution images



- Value added products
  - **OPT/ AIS merged products** (in case of available AIS Data)
  - ASCII ; KMZ, GML; VDS (EMSA); ESRI shape; JSON; GeoTIFF

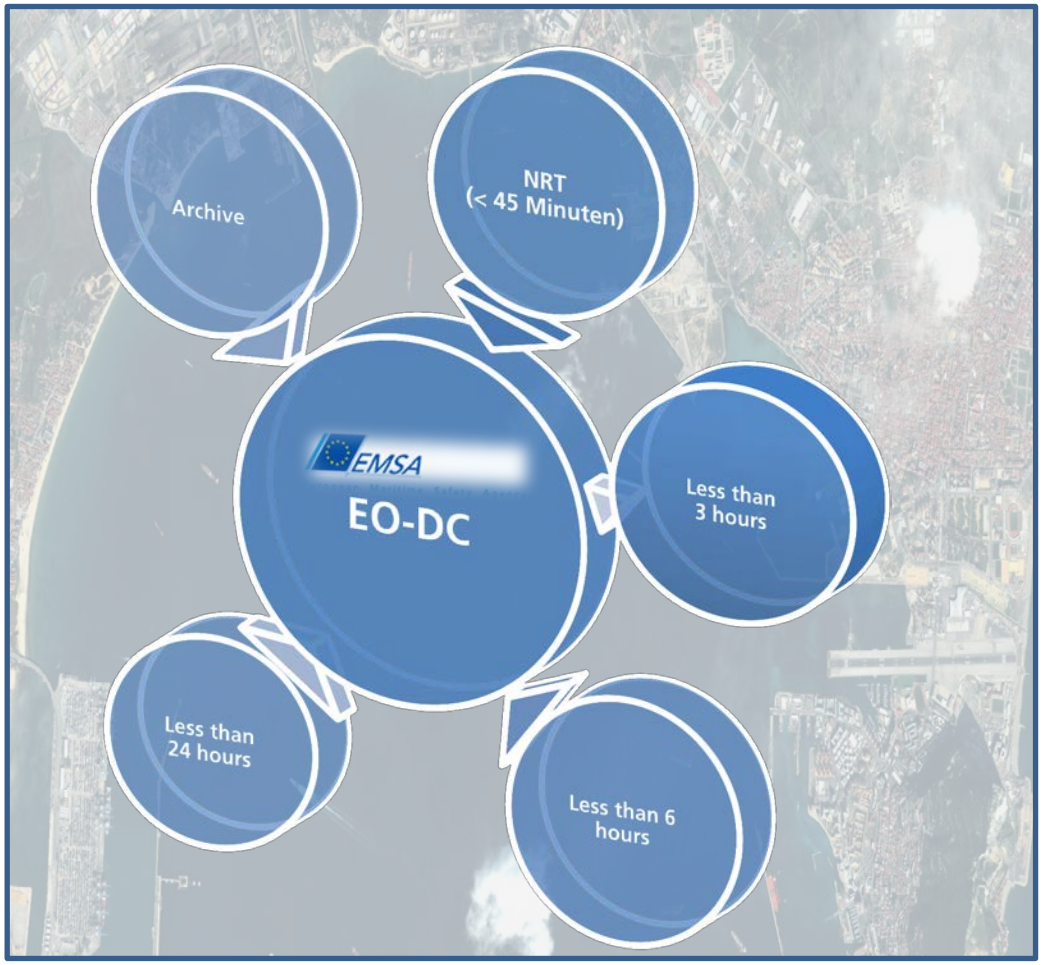
Optical Satellite Services for the European Maritime Safety Agency EMSA (OpSSERVE)

partner: EUSI (contractor) and DLR (subcontractor)

Project summary: **rapid access to satellite data and derived information** for use in maritime situational awareness based on WorldView - (1, 2, 3, and 4), GeoEYE-1, Deimos-2, Landsat-8

Direct delivery of information to EMSA Earth Observation Data Centre (EO-DC)

- Derive Value Adding Information
  - **Vessel detection**
  - **Vessel activity detection**
  - **Change detection**

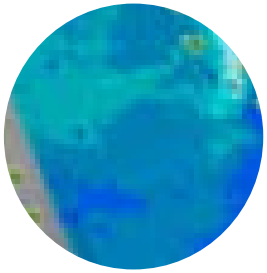


EMSA European Maritime Safety Agency

European Space Imaging

DLR

SAR based Wind Detection



Near real time Wind detection application based on SAR images
core function is the XMOD, CMOD processor developed at the Maritime Security Lab Bremen

currently developed for:
TerraSAR-X, TanDEM-X
Radarsat-2, Sentinel-1A,
Sentinel-1B

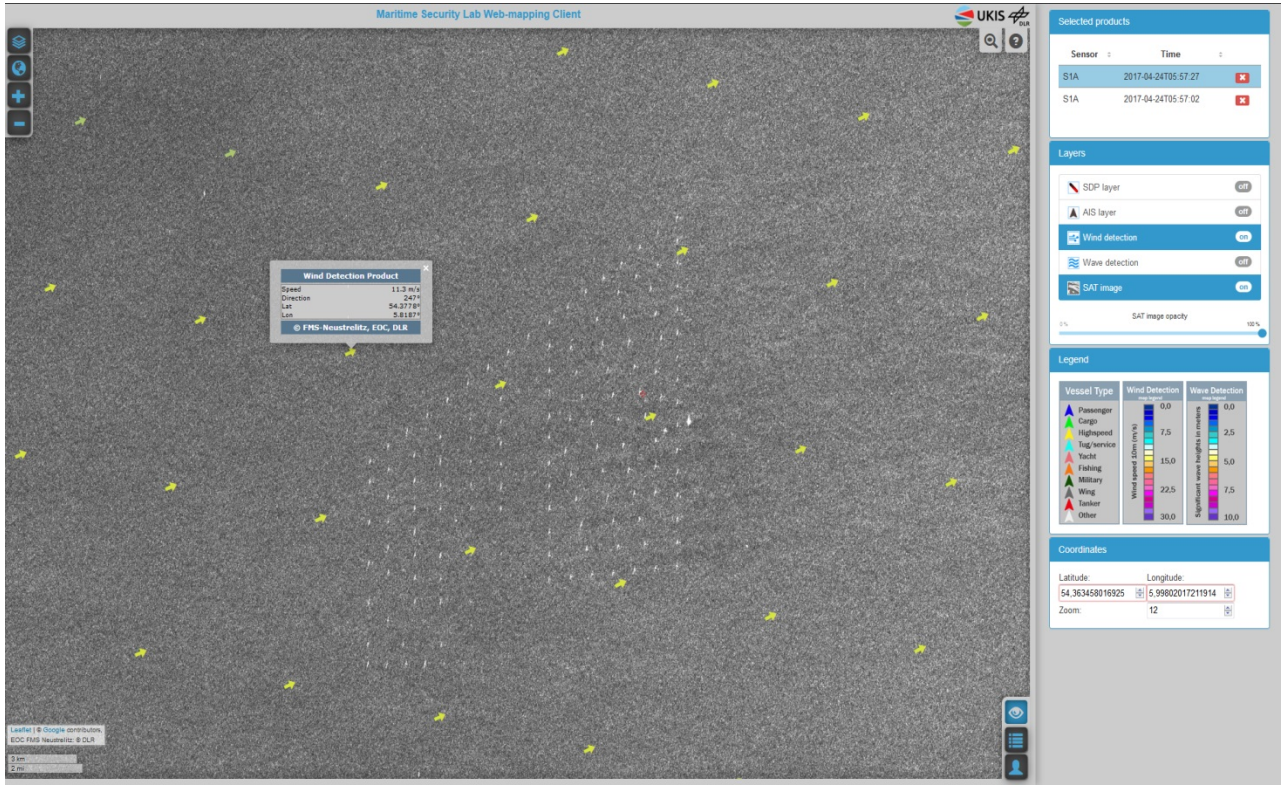
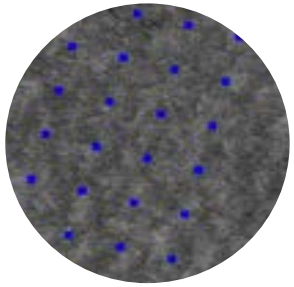


Image: S1A_IW_GRDH_1SDV_20170724T0527

DLR SAR WIND product (rectangles) derived from the Sentinel image and Level 1 quicklook product as background.

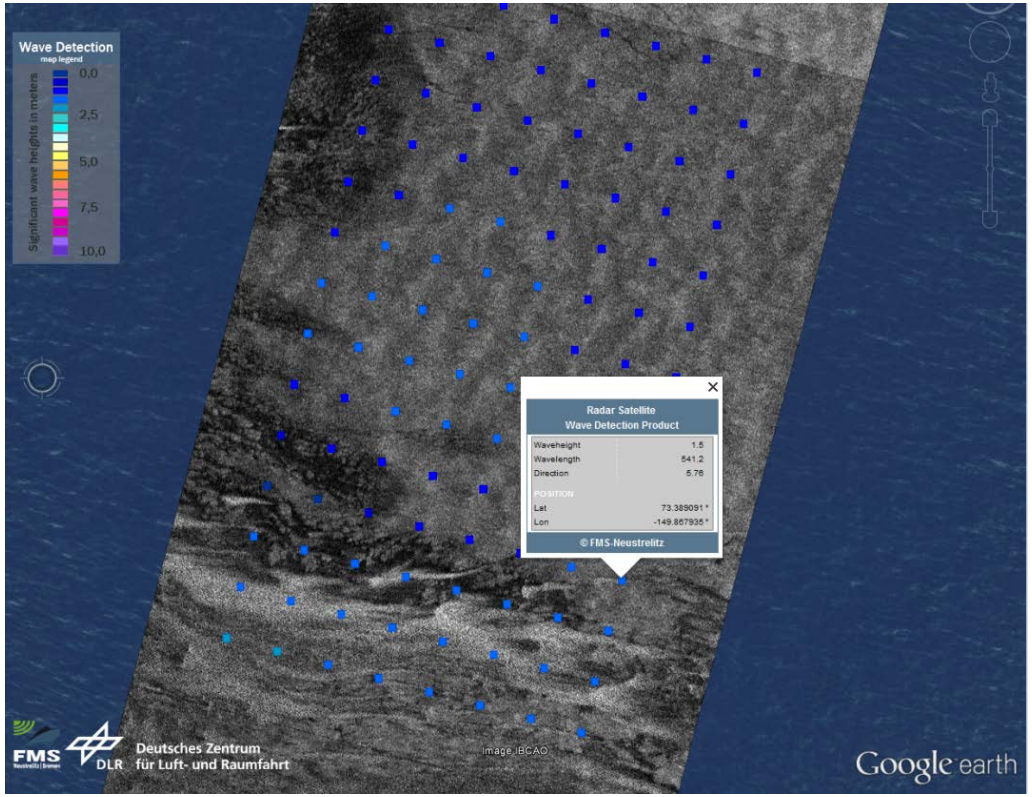
Ackn: S.Jacobsen; DLR- IMF

SAR based Wave Detection



Near real time Wave detection application based on SAR images
core function is the XWAVE, CWAVE processor developed at the Maritime Security Lab Bremen

currently developed for:
- TerraSAR-X, TanDEM-X
- Sentinel-1A, Sentinel-1B



DLR SAR WAVE product (rectangles) derived from the TerraSAR-X StripMap image, L1 quicklook product as background.

Ackn: A. Pleskaschevski; DLR- IMF

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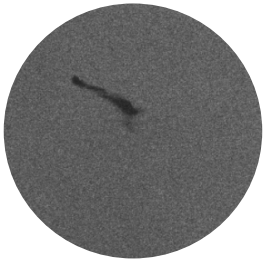
SAR based Oil Spill Detection

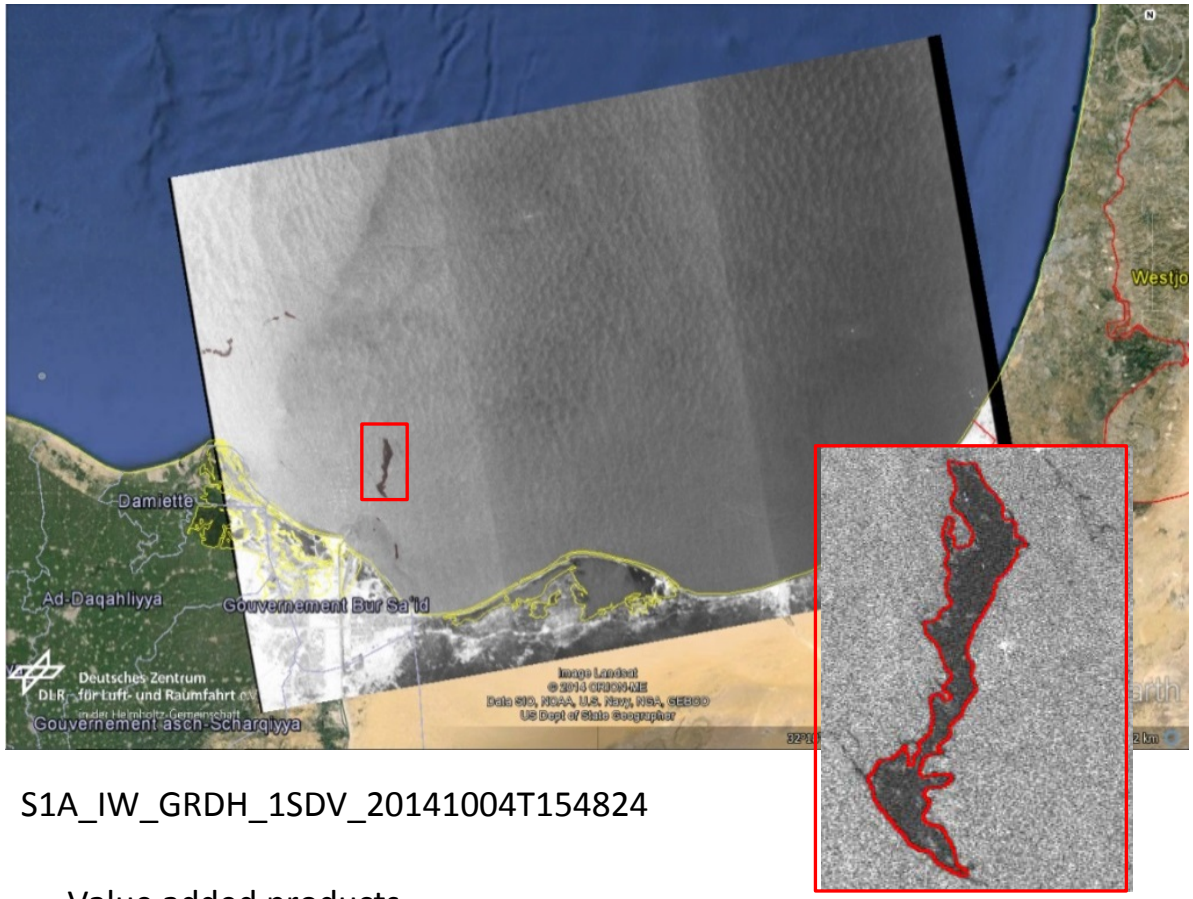


Near real time oil spill detection application based on SAR images
core function is the qualification algorithm developed by the Maritime Security Lab Bremen based on Neural Network

currently developed for:

- TerraSAR-X, TanDEM-X
- Sentinel-1A, Sentinel-1B
- Radarsat-2

Ackn: S. Singha; DLR- IMF



S1A_IW_GRDH_1SDV_20141004T154824

Value added products

- ASCII ; KMZ, GML; OSN (EMSA); ESRI shape; pdf;
- GeoTIFF (MRES_L1b; HRES_L1B)

Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

EMSec
ECHTZEITDIENSTE FÜR DIE MARITIME SICHERHEIT security

Objective

Situational Awareness
- improve revisit time and near real time capabilities
- deliver SAR/ Optic derived target detection information
- deliver SAR derived wind and wave information
- improve data fusion methods and anomaly detection
- improve detection quality of hazardous materials and classification
- development of HMI interfaces

Navigation
- improve secure navigation
- protection of navigation systems (spoofing, jamming)

AIRBUS DEFENCE & SPACE
ATLAS ELEKTRONIK A joint company of ThyssenKrupp and EADS
Technisches Hilfswerk
Universität Rostock Traditio et Innovatio
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft
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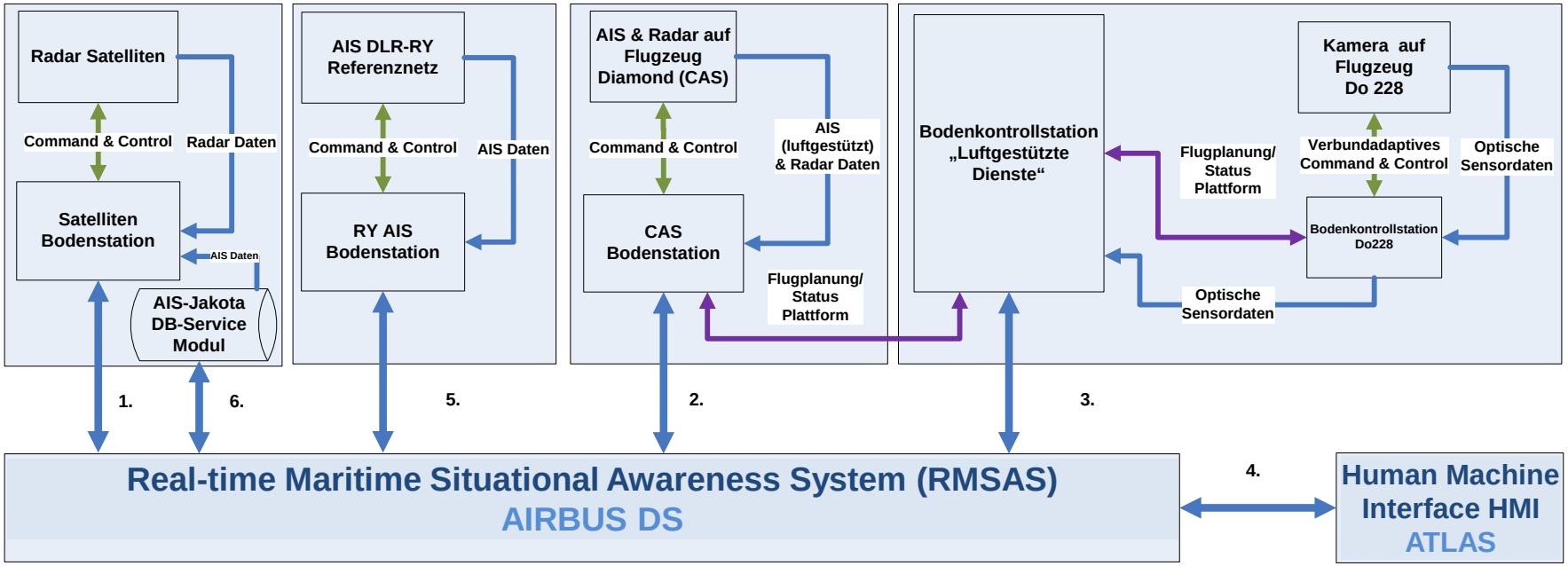
Project Real Time Service for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

EMSec
ECHTZEITDIENSTE FÜR DIE MARITIME SICHERHEIT security



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Project Real Time Services for Maritime Security
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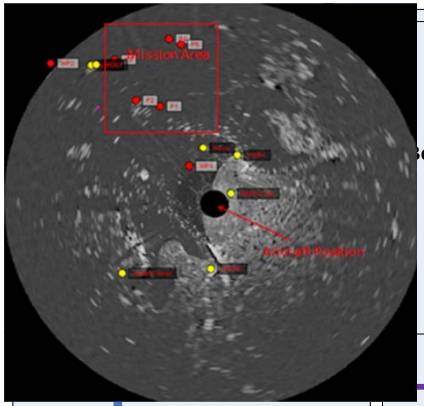

1. 6. 5. 2. 3.

Real-time Maritime Situational Awareness System (RMSAS)
AIRBUS DS

4.

Human Machine Interface HMI
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Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

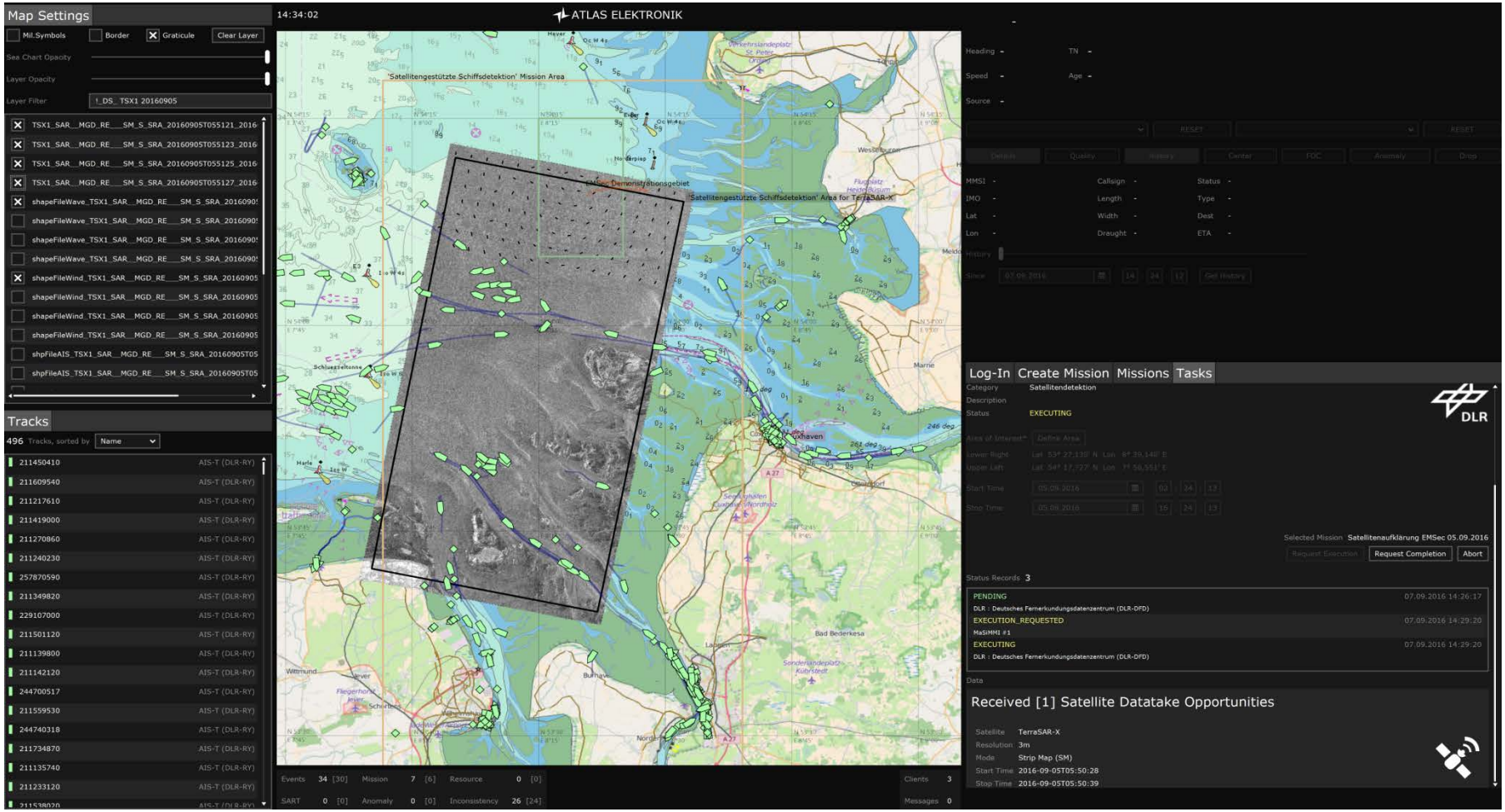
EMSec
ECHTZEITDIENSTE FÜR DIE MARITIME SICHERHEIT security

Test Scenarios

- vessel monitoring and detection of anomaly behavior, simulation of hijacked ferry
- detection of people who have gone overboard based on AIS-Search And Rescue Transmitter (SART)
- observing pollution of hazardous substances
- jamming and spoofing – suppression of interference and decoy signals at sea

Project Real Time Services for Maritime Security
Echtzeitdienste für die Maritime Sicherheit – Security - EMSec

EMSec
ECHTZEITDIENSTE FÜR DIE MARITIME SICHERHEIT security



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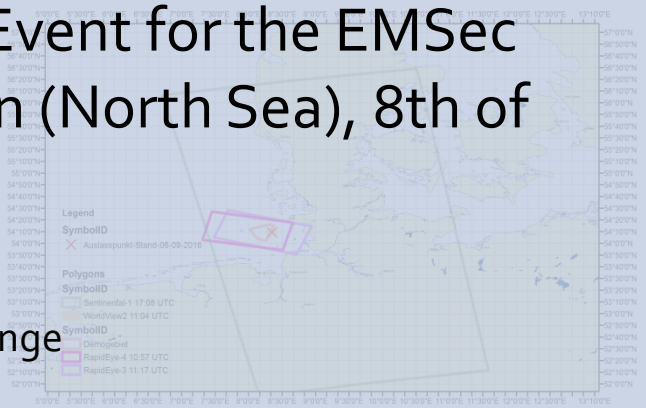
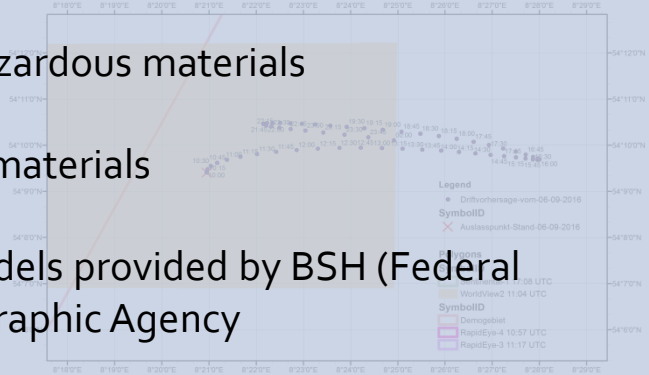
Example: Optical Sensor based Hazard Detection

EMSec
ECHTZEITDIENSTE FÜR DIE MARITIME SICHERHEIT security

Demonstration Event for the EMSec Project Cuxhaven (North Sea), 8th of September 2016



- Real-Time data exchange
- Data fusion capabilities
- Detection of liquid hazardous materials
- Tracking of detected materials
- Validation of drift models provided by BSH (Federal Maritime and Hydrographic Agency



http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10081/151_read-19273/

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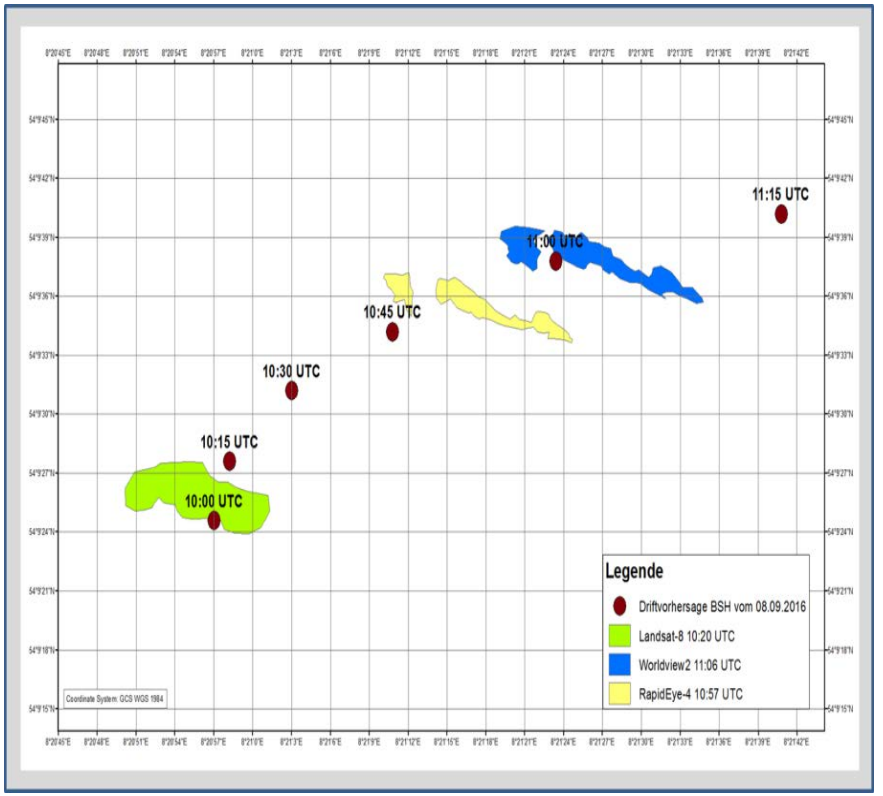
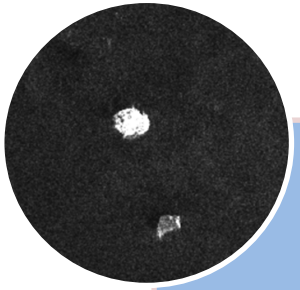
Example: Optical Sensor based Hazard Detection

- Validation of drift models provided by BSH (Federal Maritime and Hydrographic Agency



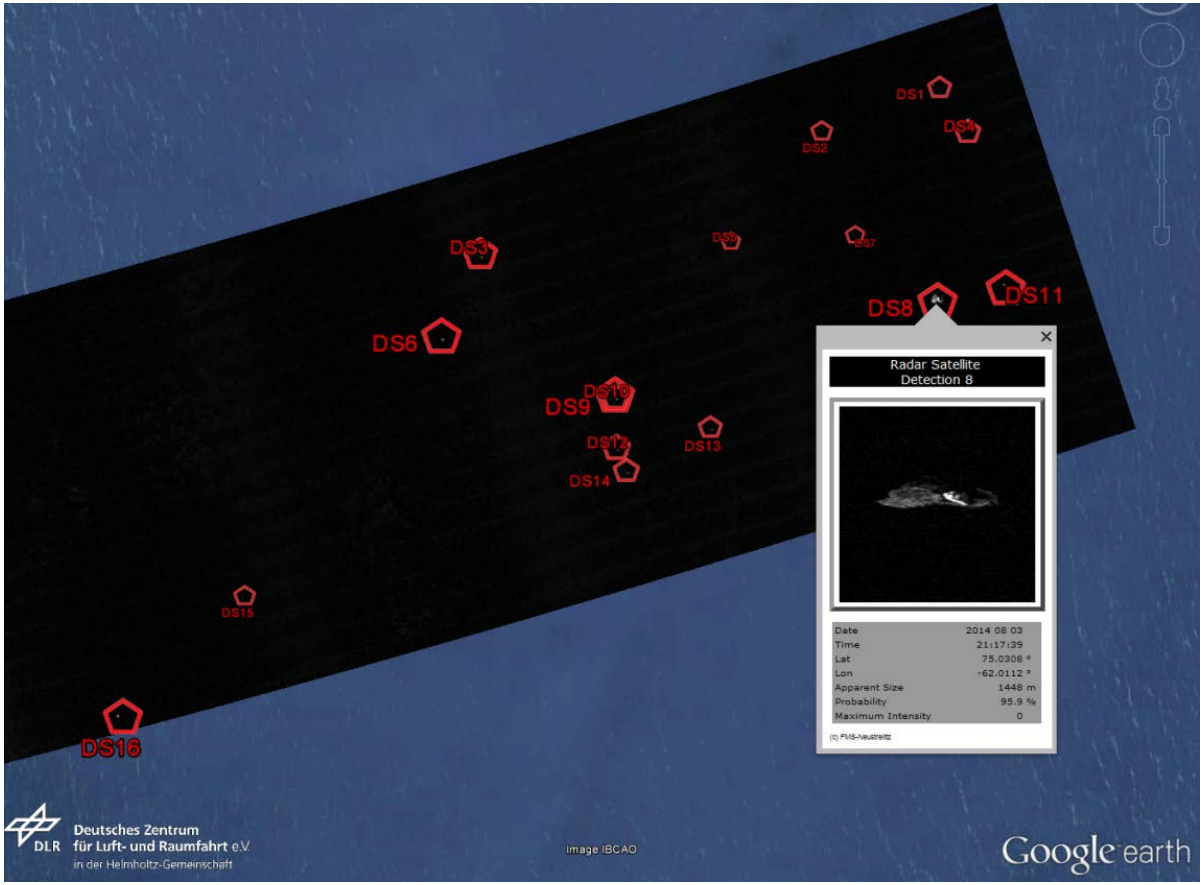
Outlook SAR Iceberg Detection



Near real time iceberg detection application to Support Maritime Situation Awareness

- Ice Service Center
- Support Exploration Management and Resource planning
- Route management

Ackn: A. Frost; DLR- IMF

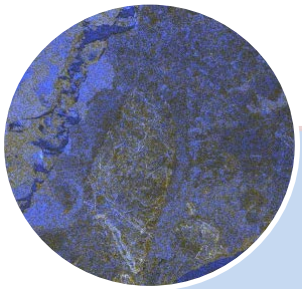


TerraSAR-X ScanSAR Mode, Polarisation: HH, 150 km range,

Frost, Anja und Ressel, Rudolf und Lehner, Susanne (2015) Iceberg Detection over Northern Latitudes Using High Resolution TerraSAR-X Images. In: 36th Canadian Symposium of Remote Sensing - Abstracts. 36th Canadian Symposium of Remote Sensing, 8.-11. June 2015, ST. JOHN'S, NEWFOUNDLAND AND LABRADOR, CANADA.

DLR

Outlook SAR Ice Classification

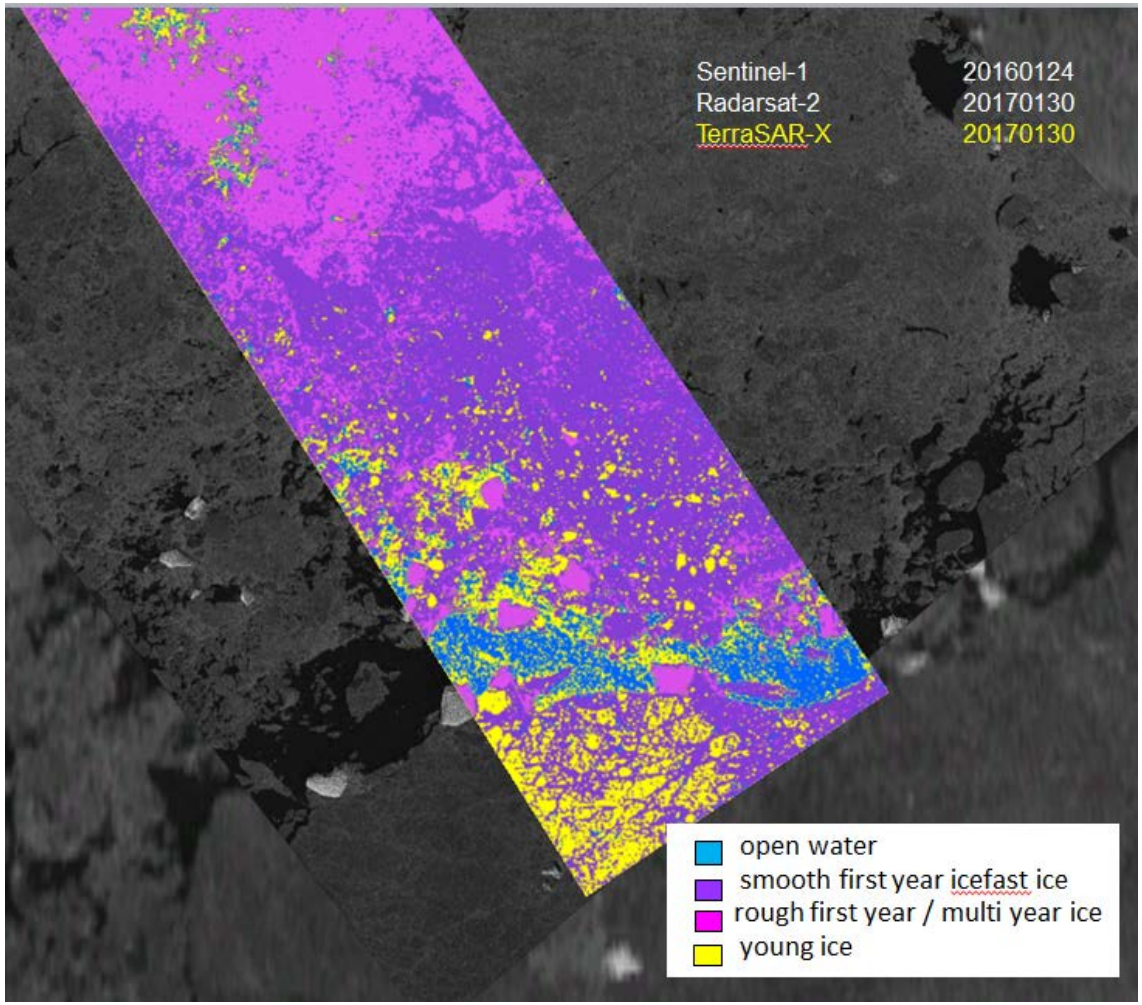


Near real time Ice drift application to Support Maritime Situation Awareness

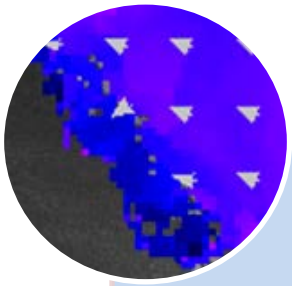
Core processor currently being developed by the Maritime Security Lab Bremen

Planned value added products based on TerraSAR-X (DualPol)

Ackn: S. Singha; DLR- IMF



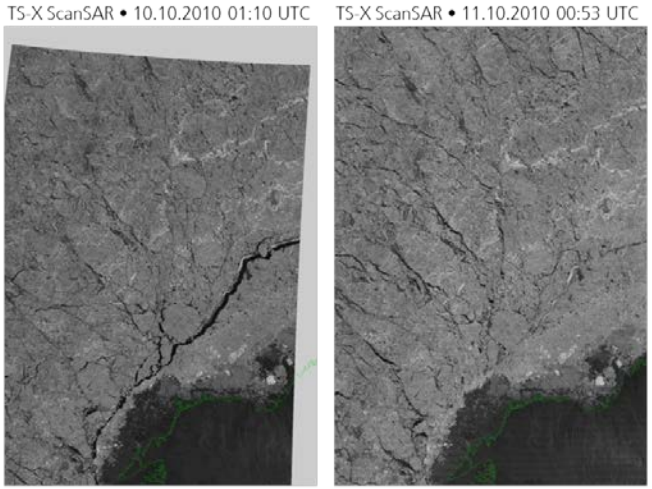
Outlook SAR Ice Drift

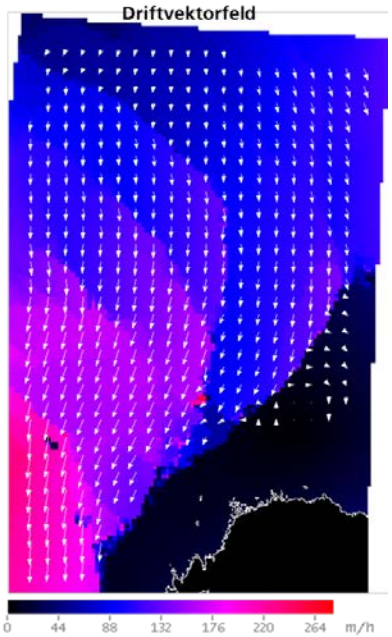


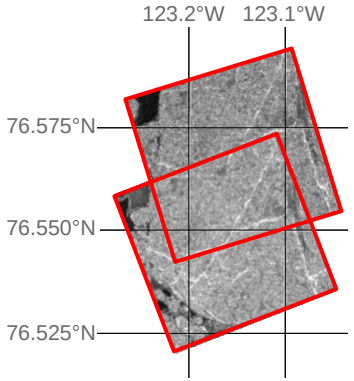
Near real time Ice drift application
to Support Maritime Situation Awareness

Core processor currently being developed by the Maritime Security_Lab Bremen

planned value added products in near real time based on TerraSAR-X, Sentinel-1 and Radarsat-2

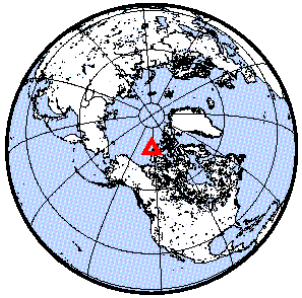






10.10.2010

11.10.2010



Conclusion

- ✓ SAR Applications like Oil Spill Detection or Ship Detection based on SAR Satellite images and AIS for Maritime Domain Awareness are proven and established.
- ✓ Optical Satellite Services based on very high resolution images being developed.
  - ➢ Operator supervision still required

- ✓ Near Real Time Services are one of the Key Performance Indicator

- ✓ **New Satellites / Satellite Constellations** enable
  - ✓ Advanced revisit time and update rates
  - ✓ New and innovative Products
  - ✓ Enhanced availability of data

- ✓ Complimentary Airplanes and/ or RPAS Solutions extends the monitoring capabilities

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